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Acetabulum fracture: Operative and conservative management

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Abstract
Acetabular fractures are uncommon compare to other polytrauma setting, and most orthopaedic surgeons will never develop a wide exposure to them. Earlier management of these injuries can have major effects on the long term outcomes from what is often a significant injury in a young patient. We present a current review of the anatomy, classification and management guidelines for acetabular fractures, including a comprehensive review of the major decision making processes, as well as describing the most common complications and the outcomes.

Keywords: Hip fracture, bone turnover markers, CTX, PINP, Vitamin D

Introduction
Acetabular fractures are uncommon in comparison to other fractures – the average orthopaedic surgeons will never see a large or regular numberof cases. The management of these injuries has become a sub-speciality within orthopaedics, and generally takes place in a tertiary level health care setup. While this process is relatively simple but this fracture cases, also associated with other injuries, so management and decisions require communication amongst surgeons, different specialities and different hospitals. With current scenario inter-hospital transfers are rare because of multispeciality healthcare setup –these must be minimised in order to afford the patient every chance of the best outcome possible. Acetabular fractures are most common in young patients, occurring as a result of road traffic accident and other high velocity injuries. Poor outcomes result in a significant burden on the patient and their support system for many years. An appreciation of the principles of early management of acetabular fractures, as well as a good relationship with the local specialist centre will go a long way towards achieving the best results possible.

History
History of the surgical treatment of acetabula fractures is brief. Prior to the late 1960s, acetabular fractures were usually treated non-operatively, and poor outcome were common (Figure 1). Exposure of the acetabulum was seen as difficult, and fixation even more so, and few cases existed to suggest that surgery was beneficial. In 1948, Armstrong reported on 101 cases of traumatic hip dislocation during the second world war, but only 50 had an acetabular fracture, 43 being of the posterior rim. Of these, only one case was treated surgically, and only 15 had follow-up beyond 12 months. In 1951, Thompson and Epstein reported their long-term results of 116 cases. Those cases with a minor posterior fracture or a large single posterior fracture that reduced closed and were stable uniformly did well, whereas more complex fractures or those that were unstable after closed reduction did less well. A delay in reduction appeared to compromise outcome, but numbers were small. They stated that if incongruity or instability could be avoided with surgery then it may be possible to reduce the incidence of arthritis, but overall, outcomes depended mainly on the fracture pattern and early diagnosis. Stewart and Milford in 1954 discussed 128 cases, out of which 33 receiving surgery, and came to similar conclusions. They also stated that in the absence of instability there was no need for immobilisation or traction. In 1961, Rowe and Lowell published a series of93 fractures, and in subset of 23 cases clearly shows that displaced fracture of the weight-bearing dome fared much better if the fracture was reduced anatomically and congruence achieved.

In 1964, Judet recommended anatomic reduction and internal fixation for all displaced acetabular fractures, and in the same paper described the now standard classification of acetabular fractures. Following this, surgical management became more common, and several reports (Letournel, 1980; Matta *et al*., 1986a, b; Giannoudis *et al*., 2005) [21, 25, 26, 6] appeared in the report showing good and excellent results from surgery. As a result, surgical management is now the standard for any displaced acetabular fracture in the absence of extenuating circumstances. The remaining issues are related to which fractures to treat non-operatively, how fixation can be achieved with minimal risk to the patient, or when a total hip replacement is more appropriate.

Epidemiology

Prior to the introduction of the motorcar acetabular fractures were rare. The incidence of acetabular and pelvic fractures today is approxi-mately 1 in 50 000 population per year in the UK, and they are stated to represent 2% of all fractures. The incidence has decreased since the introduction of seatbelt but overall has remained largely constant over most of the last20 years. What appears to have improved over this time is the associated mortality, which may represent either a decrease in the overall rate of polytrauma, or an improvement of its management in the UK. The number that any one centre will see depends much on the surroundings of the hospital, whether urban or rural, and the proximity of major roads. The primary cause of acetabular fractures remains road traffic accidents, with a causal rate of between40% (Laird and Keating, 2005) [20] and 76% (Madhu *et al*., 2006) [22]. Other causes include falls, pedestrians hit by vehicles and less commonly sports injuries. Repeatedly, the most common fracture pattern seen is the associated both column fracture (Figure 2), followed by transverse, posterior wall, or a combination of both (Matta *et al*., 1986; Giannoudis *et al*., 2005; Madhu *et al*., 2006) [25, 26, 6, 22], and the hip dislocation rate is 15–40%. According to the largest study published (Giannoudis *et al*., 2005) [6], the average age of patients is 39, and 2 out of 3 cases are male. In the same paper, sciatic nerve palsies were seen in 16% of cases, but this rose to 40% when there was a dislocation. A total of 40% of cases had an associated extremity fracture, 22% had a head injury and 20% chest or abdominal injuries. Although there is no data to support this yet, the current trend at the authors institute is of an increase in the number of fragility fractures, or fractures from simple falls. This is possibly due to a combination of elderly patients becoming more active, and osteo-porosis becoming more common. The challenges for this group are different, as the fractures are commonly complex or unclassifiable, and secure fixation is difficult to achieve in poorer bone. The patients also regularly have significant medical comorbidities, making anaesthesia more challenging. Whether this reflects a real trend remains tobe seen, but the general aging of the population would seem to support it as likely to continue.

Bony anatomy

The acetabulum is the deep, cup-shaped structure that encloses the head of the femur at the hip joint. It is interesting to note that the acetabulum is formed by a combination of all three bones of the pelvis: the ilium, pubis, and ischium.

The lunate surface is the horseshoe-shaped articular superior surface of the acetabulum. Heavily lined with articular cartilage, it is the only part of the acetabulum that normally contacts the femoral head. The acetabular fossa is a depression deep within the floor of the acetabulum; normally, the fossa does not contact the femoral head and therefore is not lined with articular cartilage.

The acetabulum itself is found where all the three pelvic bones that form the innominate bone meet, and in childhood is the site of the tri-radiate cartilage. It is formed of two columns, anterior and posterior, with the quadrilateral plate sitting in-between. The anterior column is larger when seen from both inside and outside, but the bone of the posterior column is thicker and stronger, and includes much of the very dense sciatic notch. In addition to this, fractures can involve the anterior or posterior walls, and may be above, through or below the acetabular dome.

The adult acetabulum contains components of the ilium, ischium, and pubis, which together form the innominate bone. The acetabulum contains anterior and posterior walls but is open inferiorly as the acetabular notch.

Soft tissue anatomy

The acetabulum is lies deep within the body, and no part of it is superficial. Access from any direction can be difficult, and the operating surgeon must have knowledge about soft tissue anatomy around it. Anteriorly, it is crossed by the inguinal canal, with the femoral bundle and the ilio-psoas tendon beneath. At the lateral extent of the inguinal ligament is the lateral femoral cutaneous nerve, which is in danger in the ilio-inguinal approach. The exact site of the nerve is very variable, with it passing either through, above or below the inguinal ligament, and it can be found anywhere from 10 to40 mm medial to the ASIS. More laterally, the acetabulum is cloaked by gluteal muscles, which extend posteriorly, covering the superior gluteal neurovascular bundle. In posterior column fractures, the fracture almost always exits superiorly somewhere in the region of this bundle, making fracture exposure and fixation more complex. The sciatic nerve is in close proximity as it merges from within the pelvis via the greater sciatic notch, descending posterior to the hip joint. Surgeons must always be wary of the sciatic nerve, as the anatomy of this region is variable. Although in most cases the two portions of the sciatic nerve join before it leaves the pelvis, in some cases the division continues much lower. These two divisions can run together, or on occasions are seen to lie either side of piriformis muscle – this leads to an increased risk of nerve injury both by the injury itself or by the unwary surgeon who identifies only one half of the nerve. Medially is the obturator membrane, with the obturator vessels and nerve coursing through their canal to pass laterally just beneath the fovea, and just internal to this is the bladder. Also crossing the pelvic brim medial to the acetabulum in approxi-mately 10% of people is an abnormal arterial communicating artery, known as the coronamortis, which joins the internal and external iliacartery systems. Damage to this artery causes significant bleeding as the arterial flow can be from both cut ends.

Classification

The type of fracture, and direction of dislocation if present, depends on a combination of the position of the femoral head at the time of injury and the direction of the applied force. There are also natural weak areas in normal bones, and fractures are often seen to pass through certain areas such as through the thin portion of the iliac wing or through the site of old epiphyseal scars.

Letournel’s classification of acetabular fractures is based on plain X-ray findings. Fractures are divided into 10 types, of which 5 are simple patterns (involving only one fracture line) and 5 are complex (with more than 1 fracture line) the five simple fracture patterns cover all.

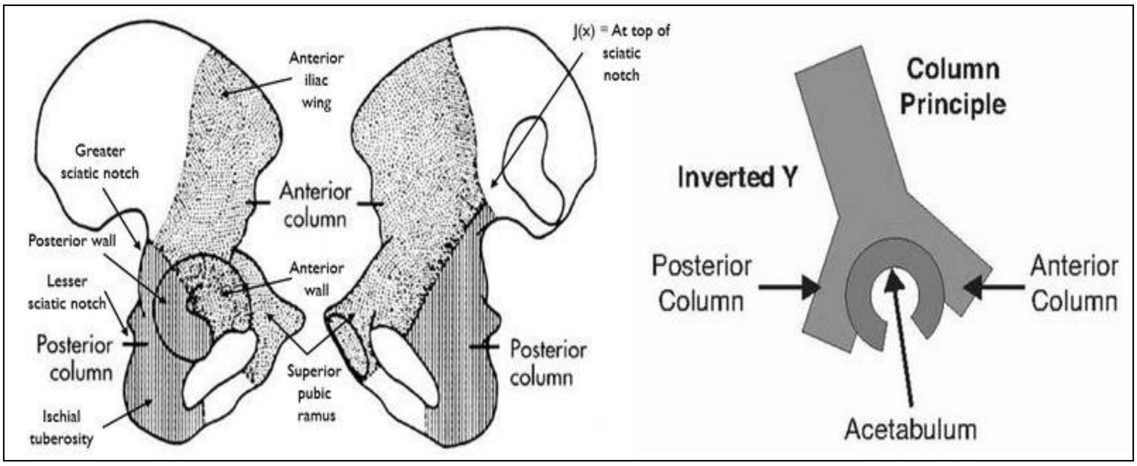


Fig 1: Columnar concept – Judet and Letournel

options for where a single fracture line could pass. If these were combined in all possible ways to include any 2 fracture lines, there would be 13 possible complex fracture types. However, some fracture combinations are very rare (e.g. posterior column anterior hemi-transverse), hence there are a total of 10 fracture types in the final classification system. Accurate classification is essential, as it aids surgical planning and gives important information regarding the fracture prognosis. Pre-operative identification of factors such as marginal impaction and the degree of displacement give clues as to the likely technical problems that may lie ahead, including the identification of displaced fragments, which may block reduction. The associated both column fracture is the only fracture pattern where none of the articular surface is in continuity with the remaining ilium above. This occasionally allows for a situation where secondary congruence can occur – the acetabular fracture fragments reform in a congruent fashion around the femoral head, although all are removed from their original position.

Cause of acetabulum fracture

An acetabular fracture results when a force drives the head of the femur against the acetabulum. This force can be transmitted from the knee (such as hitting the knee against the dashboard in a head-on car collision) or from the side (such as falling off a ladder directly onto the hip). Depending upon the direction of the force, the head of the femur is sometimes pushed out of the hip socket, an injury called hip dislocation.

When the fracture is caused by high-energy impact, patients often experience extensive bleeding and have other serious injuries that require urgent attention.

Acetabular fractures are sometimes caused by weak or insufficient bone. This is most common in older patients whose bones have become weakened by osteoporosis. Although these patients do not often have other injuries, they may have complicating medical problems, such as heart disease or diabetes.

Diagnosis

Diagnosis of acetabular fracture is based primarily on plain X-rays, and the standard films are an AP pelvis and good quality Judet views. The 45 degree oblique Judet views represent the AP and lateral views of the acetabulum, whereas the AP pelvis provides a composite image. On the AP X-ray, the viewer should identify five lines and five zones. Five lines: Ilio-ischial, Ilio-pectineal, Dome, Anterior wall and Posterior wall. Five zones: Iliac wing, Obturator foramen, Teardrop, Pubic symphysis and Sacro-iliac joints The Judet views then give further information about the columns and walls. The obturator oblique shows the anterior column and posterior wall while the iliac oblique shows the posterior column and anterior wall. These views are taken by tilting the patient to the beam, leaving the beam parallel to the plate except in emergency CT is best modality to diagnose it. CT allows more precise imaging of the fracture pattern, as well as a clearer definition of fracture displacement. The dome on plain films is a composite view of a narrow area, and CT is useful to assess fracture displacement in this region. It is not uncommon for fractures to be seen on CT is useful to assess fracture displacement in this region. It is not uncommon for fractures to be seen on CT scan, which were not visible on the plain X-rays, and CT may also reveal loose bodies within the joint, as well as areas of marginal.

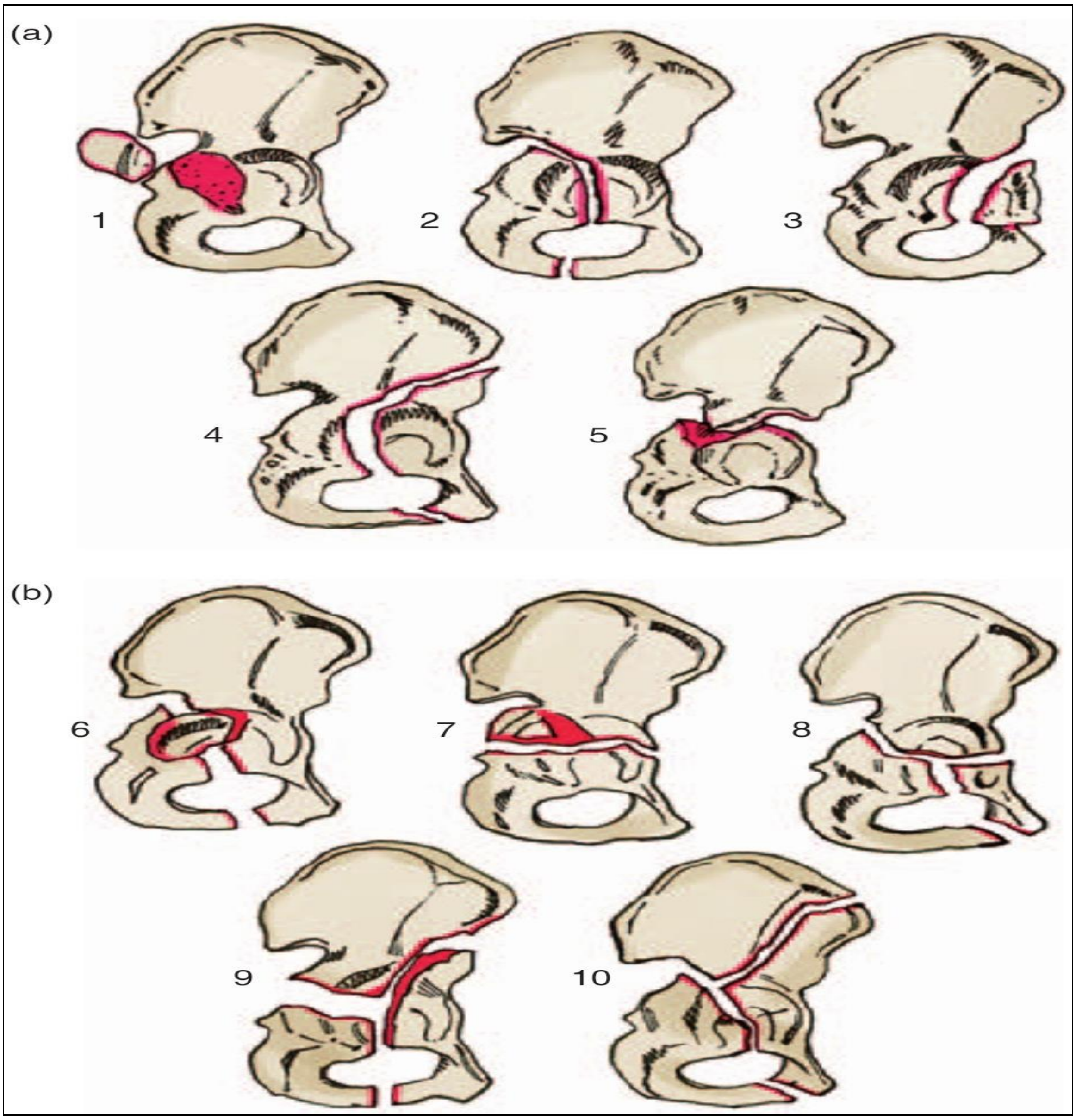


Fig 2: (a) Simple fracture patterns - 1: posterior wall, 2: posterior column, 3: anterior wall, 4: anterior column, 5: transverse (b) Complex fracture patterns - 6: posterior column and wall, 7: transverse posterior wall, 8: T-shaped fracture, 9: anterior column posterior hemitransverse, 10: associated both column

impaction (Figure 8). Parallelism of the joint space, however, is still best assessed on a plain AP X-ray.

Natural History

The only most important for better outcome of an acetabular fracture is that the femoral head is central and parallel under the acetabular dome (i.e. fully congruent) and remains there with physiological loading. Other factors, which are also important is articular surface damage, soft tissue and nerve/vascular injuries, as well as patient age and functional demands. Congruency is a 3D concept, and must be judged in at least two planes. It is often the case that a femoral head will appear well placed beneath the acetabular dome on the AP film, but with oblique views it is seen to be subluxed. Displacement of the acetabular articular surface leads to joint surface incongruity, and a decrease in the surface areas incontact between the femoral head and the acetabulum. This results in excessive forces being spread over a smaller joint area during weight bearing, which in turn will lead to damage and death of chondrocytes and the subsequent development of osteoarthritis. Instability has similar effects, resulting in abnormal loading also.

Indications of surgery

There are certain cases where to operate is obvious, such as a young patient with an unstable hip, other factors such as age, medical condition, bone quality, associated injuries and patient expectations also play a part. Absolute indications are few and uncommon, but include open fractures, the irreducible dislocation, fractures with vascular injuries, significant loose fragments in the joint as well as the rare occasion when sciatic nerve function decreases after a closed manipulation of dislocation. Although non-operative management can be successful for some fractures, surgical intervention is indicated in most displaced fractures, and allows earlier mobility and return to function.

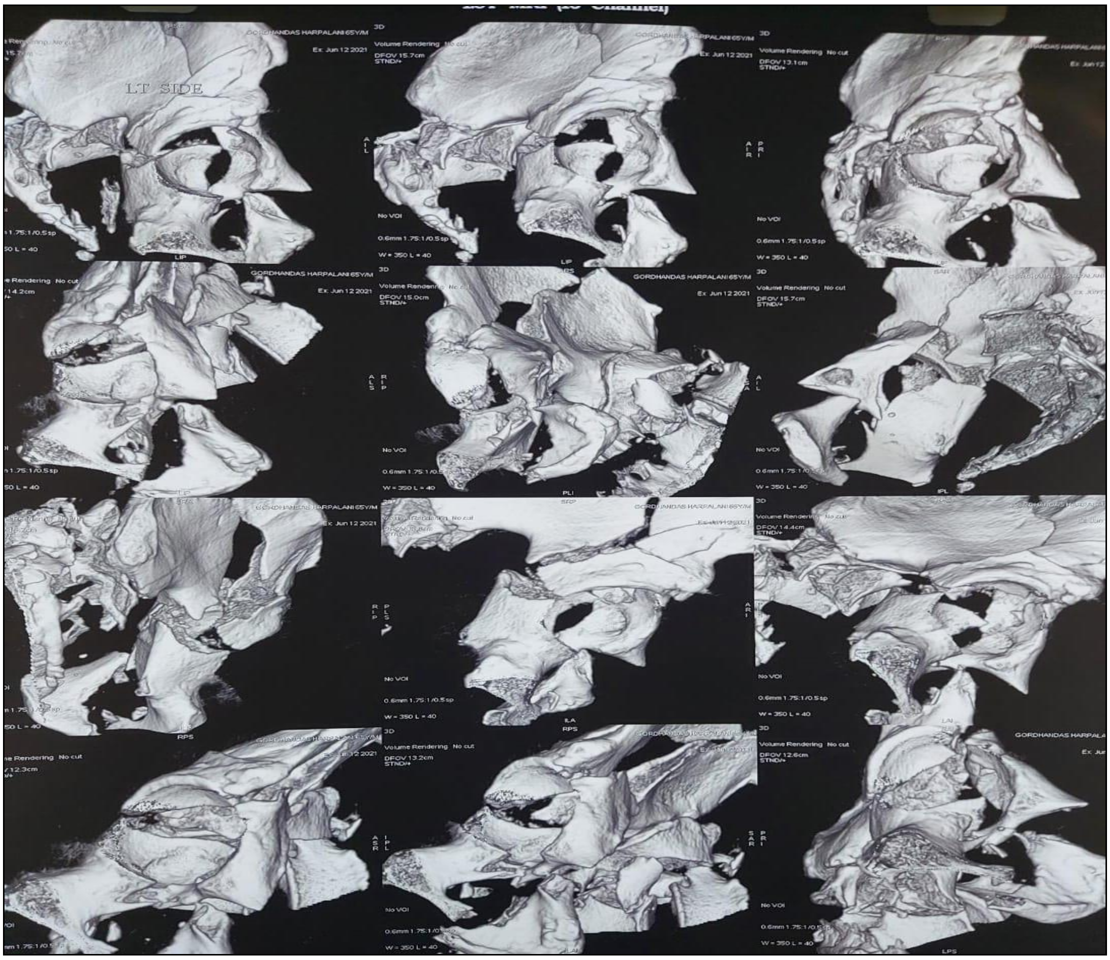


Fig 3: Three Column fracture of Acetabulum

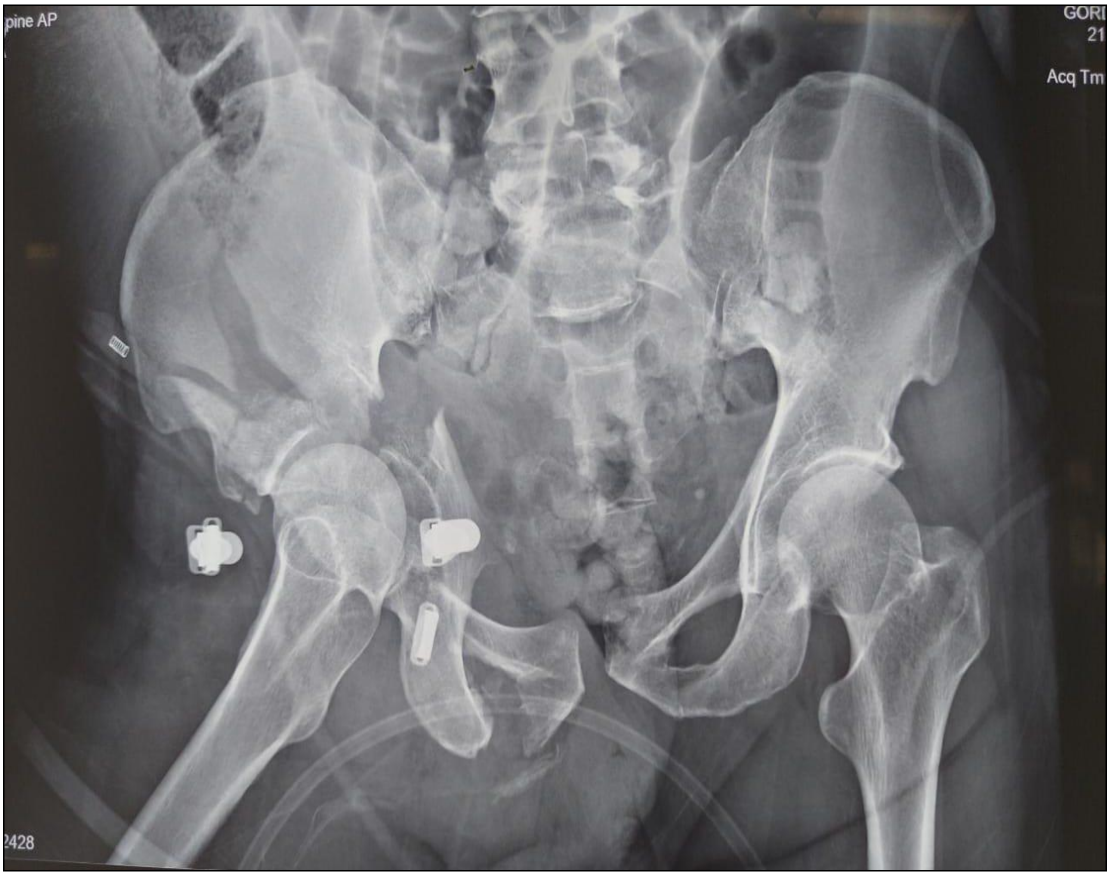


Fig 4: Fracture Acetabulum with Fracture of iliac bone

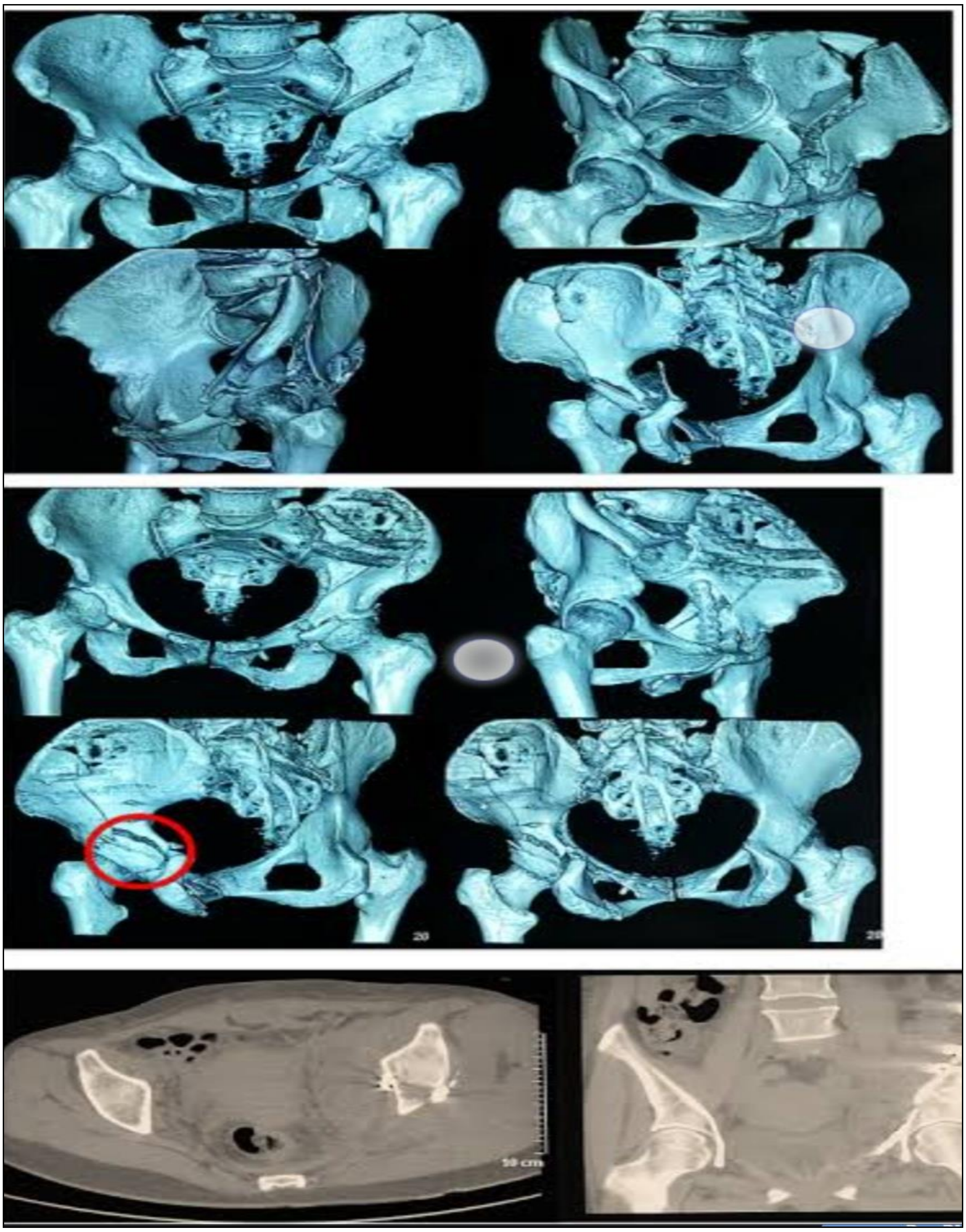


Fig 5: Figure shows in Fracture Pattern

Fracture Pattern

Isolated posterior wall fractures can be managed non-operatively if they are small and are not resulting in instability. It is important to note that a fracture cannot be diagnosed as undisplaced on a single AP film, and Judet views or a CT are necessary. The size of wall fracture that can be accepted is not known, but in past many surgeons accept up to 50% of the width of the wall on CT. Any history of dislocation should result in surgical fixation. If there is doubt then an EUA may be informative – this involves a general anaesthetic and the use of an image intensifier in theatre. The surgeon attempts to recreate the injurious forces, which usually involves flexion and adduction of the hip and rotation combined with posterior force. If the hip cannot be dislocated, and the fracture fragments do not displace further on image intensifier views, then the injury is deemed stable. Some transverse fractures cross the acetabulum below the equator of the femoral head, leaving the larger part of the weight-bearing surface intact. If the joint is stable and remains congruent then these can also be treated non-operatively. Many low anterior fractures are really extensions of superior rami fractures that happen to enter the acetabulum – these can be managed in the same way as normal rami fractures. On rare occasions, associated both column fractures that have developed true secondary congruence may also be treated non-operatively, especially if reduction and fixation is likely to be very complex or dangerous to the patient.

Degree of displacement

The degree of acceptable displacement is generally taken to be 2 mm, since this is the average depth of the acetabular cartilage, although this is best judged on CT scan.

For transverse fractures there are two additional methods of assessing the likely effect of a fracture displacement. The first is to calculate roofarc measurement on the AP film and both Judet views- a vertical line is drawn through the centre of the acetabulum. The angle formed between that line and one drawn from the centre of the acetabulum to the nearest point where the fracture crosses the edge of the acetabulum is measured. If the angles measured are all more than 45 Degree and there are no other indications for surgery, then non-operative management can be considered. The second method requires CT cuts -determines whether the fracture enters any part of the upper-most 10 mm of the acetabular joint surface – this has also been shown to be a good predictor of outcome from non-operativ management.

Instability

Joint instability will rapidly lead to degenerative changes, and is an indication for surgery whether the joint is mildly subluxed or frankly dislocated. An acetabular fracture does not have to be present for a dislocation to occur. Damage to the posterior soft tissues, usually with a rent in the capsule can lead to an isolated dislocation which may be more likely to occur in patients with naturally retroverted or shallow acetabulum. The dislocated hip should be reduced at the first opportunity, and usually requires a general anaesthetic. Although there is little evidence to support the argument that a delay to reduction increases the rate of avascular necrosis, the incidence has been shown to rise from 5.6% to 9.2% when a dislocation is present. A dislocated femoral head is more likely to sustain continued damage to the articular cartilage from fracture fragments, will be more painful, and risk wass further damage to the nearby sciatic nerve while still dislocated. Before any reduction is performed, however, a careful neuro-logical examination must be made and documented, as a new sciatic nerve palsy after closed reduction is an indication for emergency exploration – the nerve may have become trapped in the joint. Reduction is generally achieved with longitudinal traction, either in extension or flexion, similar to the reduction of a dislocated THR. In most cases, the application of traction (which should be skeletal through the proximal tibia unless there are other fractures in the limb) will guard against re-dislocation. The gold standard is early reduction, but this requires an open approach, in which case the fracture should ideally be addressed at the same time. If the opportunity arises for the patient to be transferred that day to a tertiary centre, with a view to emergency surgery, then a transfer should be made. If, however, definitive surgery is not available for several days then it is reasonable to perform an isolated open reduction, after discussion with the tertiary centre, through the same approach that will be used for definitive fracture fixation.

Congruence

In some cases, even though the fracture fragments may no tappear to be significantly displaced, the joint is seen on the AP film to have lost parallelism – i.e. to be incongruent. This can be due to a loose body inthe joint, which may be bony or soft tissue such as the labrum. If incongruence is seen, even in the absence of obvious fracture displacement, the fracture should be explored and managed surgically. Incongruence can also develop under physiological loading conditions, and a fracture may require traction to maintain congruence. If mobilisationis commenced, then e early radiographs should be performed to identify any development of incongruence.

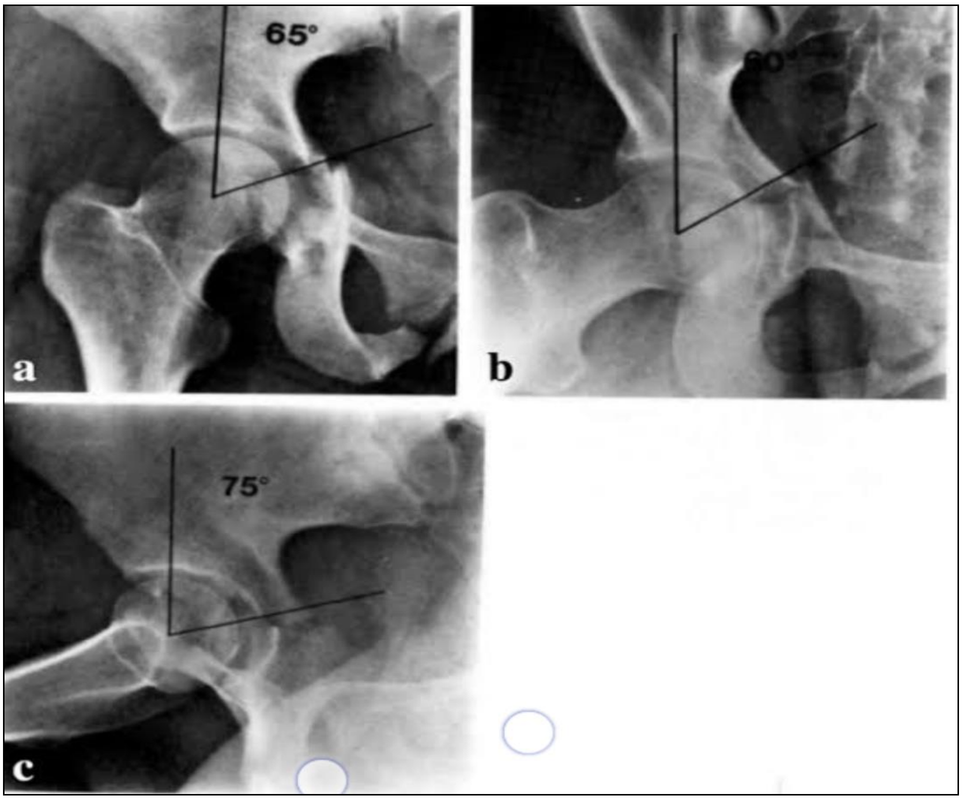


Fig 6: Figure shows in pulytrauma situation

Polytrauma

In pulytrauma situation, the acetabular fracture is rarely the prime concern, and life-threatening haemorrhage from an acetabular fracture is rare. Care must be taken, however, 1st to do is the X-ray, especially in the presence of unexplained haemorrhage, to identify the combined pelvic and acetabular fracture, which is easily missed in the presence of a significantly displaced acetabular fracture. In these cases, the pelvic fracture is treated as a source of haemorrhage and management of acetabular fracture done later on. The principle of life before limb must apply. With the exception of a dislocated hip, which should be relocated at the first possible opportunity, the acetabular fracture in polytrauma patients managed with traction while the other injuries are addressed.

Effects of associated femoral head neck or shaft Fracture

Femoral fractures are not uncommon in association with acetabular fractures, and although femoral shaft fractures are seen on plain X-rays, head and undisplaced neck fractures are easily missed. The CT scan must require to check carefully for these injuries, as they have a significant impact on the surgical plan.

Ipsilateral femoral shaft fractures

In a referring centre, the best option is to contact the tertiary centre where the acetabular reconstruction can be made and ask for their advice. The standard approach for an antegrade femoral nail will interfere with the posterior approach for acetabular surgery, not only making surgery more difficult but more importantly resulting in a higher risk of infection and heterotopic ossification. Other options include a retrograde nail or femoral plating procedure, or if rapid transfer can be arranged, simultaneous femoral nail and acetabular reconstruction procedures at the tertiary centre.

Femoral neck fractures

Combined femoral neck and acetabular fractures are not common, and pose a difficult problem. Inthe elderly patient a total hip replacement may provide the solution, but in the younger patient, reconstruction of both injuries is required. The femoral neck fracture is generally the more urgent, and should be reduced and stabilised in the standard fashion, although again discussion pre-operatively with the local tertiary centre is advisable.

Non operative Management

Aim of non-operative management is to prevent fracture displacement until healing occurs, while keeping the patient comfortable and avoiding the complications of immobility. Stable cases can be treated with non-weight bearing for 12 weeks on crutches, with check radiographs at 1, 2, 3, 6 and 12 weeks. Unstable fractures are more uncommon, and in these cases traction may be required to maintain congruence, and is best afforded through a tibial traction pin. Trochanteric traction is outdated, and should be avoided. The weight applied should not be enough to distract the joint, and is generally around 4–8 kg. The bed needs to be tilted slightly head down to avoid patient screeping towards the bottom end! In general, non-weight bearing will be required for 12 weeks, with traction only for the first 6 weeks. During traction attention should be taken for Bed sores and thromboprophylaxis. If the patient is too frail for surgery, then often the best plan is to ignore the fracture and plan for a total hip replacement when healing has occurred. Once mobility is allowed, physiotherapy is must, and provided the initial criteria for non-operative management were met a good outcome can generally be expected. Full return to activity, however, may take up to 1 year.

Adjunct to surgery

CT scan are essential not only to make diagnosis but also for making surgical planning. The exact fracture configuration is often easy to visualise in simple fracture patterns, but in complex fractures CT is must when making a surgical plan. Marginal impaction, wall fractures, some column fractures and femoral head fractures can usually only be addressed from one side.

Once in the operating theatre, screening the reduction of fractures and fixation to confirm that no screws have entered the joint requires an image intensifier. Clear communication is required between surgeons and radiographers, and generally it is possible to obtain good quality images of the reduction and fixation. No patient should leave the operating table without proof of acceptable reduction and fixation with a joint space free of hardware. In recent years, as with many other areas of orthopaedic surgery, it has become possible to use computer navigation to aid surgical fixation. It is not possible, however, for the computer to help with either achieving or assessing reduction, and this is still necessary for all cases. Navigation can be helpful for some surgeons, particularly in the passing of long column screws, which can be difficult to visualise and pass accurately on image intensifier views.

Pre-operative evaluation

In pt with acetabular fracture – a secondary survey should be repeated, with attention paid to the commonly missed injuries such as PCL ruptures, patella fractures and carpal injuries. Many cases result from blunt or major trauma, and injuries to the lungs, abdomen and kidneys are not uncommon. There is often a delay of several days between injury and definitive fracture surgery, and the effects of these injuries must not be forgotten. All patients, especially after transfer to a tertiary centre, must undergo a careful repeat secondary survey, and pre-operative tests must include renal function, liver function and clotting screen as well as chest X-ray and ECG. If multiple systems are injured then early involvement of the anaesthetic team is essential, both to plan timing of surgery and to predict the need for an ITU bed post-operatively.

Open surgical approaches.

The majority of acetabular fractures are reduced and stabilised through one of two approaches – a Kocher-Langenbeck or ilio-inguinal approach. The main factors influencing choice of approach are the fracture type and the soft tissues. In general, any fracture that is classified as an anterior column fracture should be approached from the front, and any fracture classified as a posterior column fracture should be approached from the posterior side. Transverse fractures can theoretically be reached through either approach, and unless soft tissues or other factors dictate then the approach of choice is decided based on the height of the column fractures and the degree of displacement of the relevant columns. The exception to this is the transverse/posterior wall fracture, when the wall component has to be approached from the back and allows visualisation of the anterior column fracture through the posterior wall fracture. Most of the more complex associated both column fractures are approached through the ilio-inguinal approach, although at times even this is not enough. In rare fracture types where one approach will not access all areas sufficiently, the choice is between a single extensile exposure (such as the extended ilio-femoral – or two separate approaches, which can be simultaneous, consecutive or staged a few days apart if necessary. This decision is often swayed by the experience of the surgeon involved and by the number of surgeons available (two simultaneous approaches requires two experienced surgeons). Sequential approaches gives the best of both views, but the surgeon must be careful to avoid fixation through the first approach that will compromise fracture reduction through the second. Two simultaneous approaches avoids this but to some extent compromises each approach, with neither providing the access that would be afforded by the approach done in isolation, due to problems with patient positioning. The published figures from Matta (Matta, 1996) [27] in California, shows a split of 43% Kocher-Langenbeck, 33% ilio-inguinal and 23% extendedilio-femoral, whereas in a meta-analysis that was less geographically based Giannoudis *et al*. (2005) [6] published figures of 49% Kocher-Langenbeck, 22%ilio-inguinal and only 12% extended ilio-femoral. The authors figures show an almost even split between Kocher-Langenbeck and ilio-inguinal (or variants thereof), with other approaches used only rarely. Although a single large approach intuitively appears more attractive, the extensile approaches are associated with an increased operating time, blood loss, infection rates and complications such as heterotopic ossification. As the understanding of acetabular fractures and the steps required to reduce and stabilise them have improved over time, the larger exposures tend to be used less frequently.

This is also true of a surgeons career – with experience the larger exposures used can be limited to those that are absolutely necessary for the fracture concerned. The objectives of an approach are not only exposure, but also avoiding devascularisation of the bone, and where possible minimising dissection which leads to decreased post op infection.

Patient positioning and draping

For the ilio-inguinal approach patients are posi-tioned supine, with the arms out in a crucifix position, and a pillow or similar is placed under the knee to relax ilio-psoas. If access is required to the very back of the iliac crest then a sandbag canbe placed under the ipsilateral buttock to raise this area. The genital area is carefully draped out of the surgical field – the authors both use staples to secure surgical drapes to be certain of avoiding intra-operative contamination from this area. Access is also required beyond the midline for the medial window. Patient positioning for the Kocher-Langenbeck approach is more variable, with options being lateral, prone or semi-prone. The prone approach is more unfamiliar, but allows the femoral head to fall forwards towards the anterior column, and especially if this is intact fracture reduction can be more straightforward. Access to the quadrilateral plate is also better with the patient prone. Bilateral cases are better performed prone, as no repositioning is necessary allowing simultaneous operating. For cases where two approaches are performed simultaneously a floppy lateral position can be used, where the patient is positioned lateral but can be rolled forwards or back between supports, allowing access to the buttocks or abdominal wall accordingly. Anterior access is always limited, however, as the angles of approach available to the surgeon are not ideal from either side of the operating table without the patient being supine.

Fixation methods/techniques

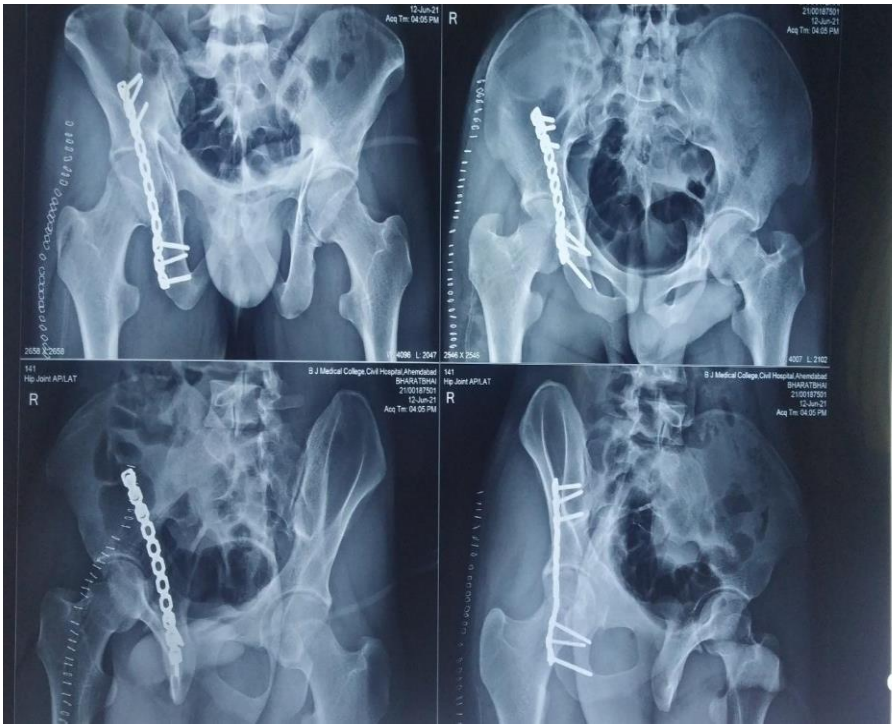
The aim of acetabular fracture surgery is to restore the joint surface anatomically and obtain stable fixation, thus enabling early mobility of a congruent joint. This allows for the best outcomes, both for the joint and the patient as a whole.

Surgical procedures can be broken down into exposure, fracture identification, reduction, fixation and closure. The surgical exposure has been covered above, but it is worthwhile to stress again that adequate exposure must be made to allow enough visualisation of the region, enabling reduction and fixation. Where possible, the joint surfaces are inspected, and note is made of the state of the femoral head. Inspection of the acetabular joint surface is the best way to assess fracture displacement. Direct Reduction – in the majority of posterior approaches the joint surface is seen through the posterior wall fracture, and the reduction manoeuvres are direct. After inspection of the joint, the fracture lines can be reduced with a combination of surgical dissection, limb traction and carefully applied pressure to the fragments. Posterior and transverse column fractures can be reduced directly, with the posterior column element usually requiring derotation using a schanz screw placed in the ischium. Assessment of anterior column reduction may require palpation through the sciatic notch. If the anterior column is intact then the femoral head can be pressed against it, and act as a template for the posterior wall fragment. A provisional fixation is usually secured using k-wires, while the adequacy of reduction is assessed – this is done using direct vision and image intensifier. Indirect Reduction – in the majority of ilio-inguinal approaches, the reduction is indirect. The articular surface is not seen, and no direct assessment can be made of the femoral head. Reduction manoeuvres involve limb traction and direct pressure on the fragments after removal of as much haematoma and callus as possible. An assumption regarding the joint surface reduction is made based on the reduction visible on the outer aspect of the acetabular bones. While the anterior column reduction is well seen through this approach, the reduction and orientation of the posterior column is less well appreciated. High posterior column fractures are within the field of vision but lower fractures less so – these may, however, be so low as to be extra-articular. Again, after reduction provisional fixation can be achieved with the use of k-wires. Surgical fixation is extremely variable, from case to case and surgeon to surgeon; however, broad basic principles apply. Where possible column fractures are secured with a lag screw, and fixation is augmented with a neutralisation plate. Posterior wall fractures tend to be fixed with a lag screw and buttress plate in combination where possible. Complex associated both column fractures often require several modes of fixation in differing locations.

Percutaneous surgery

In most branches of surgery there is a modern trend towards reducing the size of surgical exposures. While this may minimise soft tissue trauma (with benefits in the short term and later if a total hip replacement is required), it cannot be allowed to interfere with the surgeons ability to meet the objectives of surgery, safely. The use of computer navigation systems can tell a surgeon where the fragments are, and where to place fixation, but they cannot aid in the manual act of fracture reduction which is essential. There are certain circumstances, however, where percutaneous fixation has a place. These include undisplaced fractures that are potentially unstable, minimally displaced simple fractures that may be reducible with minimal open surgery, cases where soft tissue damage precludes open surgery, or where medical comorbidities are severe and the risk of open surgery with major blood loss is high. Another common situation is the undisplaced fracture in an unreliable patient, where minimal fixation may avoid secondary displacement. In complex both column fractures, it is reasonable to reduce and fix one column by an open technique, and stabilise the second column percutaneously, and in severe fractures with secondary congruence the main column portions can be fixed in situ by percutaneous means also. The main techniques are to place long screws in either the anterior or posterior columns

Fixation requires very careful screening to avoid penetrating the hip joint, and an inability to obtain clear views in all planes is a contra-indication to percutaneous surgery.



Marginal impaction

Marginal impaction is a special situation, and the surgeon have to look for this in every case. While it is sometimes visible on plain X-rays, the CT scan clearly demonstrates impaction and its extent. Unelevated marginal impaction prevents reduction of the main fracture fragments and will lead to incongruence. The increased stresses placed on the adjacent articular cartilage will lead to cartilage breakdown and the development of arthritis. The area of depressed cartilage is elevated carefully with an osteotome or similar instrument, along with a small amount of impacted cancellous bone. The resulting defect must be filled with graft, usualy from the greater trochanter. In general no fixation is required, as the femoral head will keep the elevated segment from displacement after the joint is reduced. Although previous studies showed that femoral head lesions were an important predictor of outcome, Kreder *et al*. in 2006 [19], however, reported significantly worse results for posterior fractures with marginal impaction, going so far as to suggest that in patients over 50 with severe marginal impaction a primary total hip replacement should be considered as an option. Most of acetabular surgeons would not necessarily agree with this conclusion, but the effects of marginal impaction are not insignificant.

THR (Total Hip Replacement) in acetabular fractures

Total hip replacements are generally performed at four time intervals after an acetabular fracture.

(a) Acute total hip replacement – with or without fixation.

In the acute situation, with a young patient aprimary total hip replacement would rarely done and if ever be considered, and all attempts are made to preserve the native hip joint. Work from Letournel (1981) [22], Matta (1996) [27] and Mears *et al*. (2003) all suggest that the outcome of fixation, however, deteriorates with increasing patient age, as a result of increasing comminution and unreliable fixation in osteoporotic bone. In more elderly patients, if the fracture is judged to have a poor prognosis then an acute total hip replacement has attractions (e.g. the comminuted fracture with significant wall impaction, or with pre-existing hip arthritis). Surgery is more complex, however, as fixation is required to support the hip prosthesis.

(b) Early total hip replacement after union, at 6–12 weeks

In cases where patients are too frail to undergo fracture surgery, or the joint surface fragmentation is considered unrepairable. it is an option to allow the fracture to unite with a plan for a total hip replacement soon after. The fracture is not addressed and the patient allowed home. The advantage of this strategy is to avoidance of the risks of fracture surgery, and it allows a hip replacement to be done through unoperated tissues. The risk of this strategy, however, is the development of non-union, especially if there is a significant fracture gap, which makes subsequent arthroplasty significantly more complex. Acute primary total hip replacement has traditionally yielded poor results but publications invariably used cemented implants. More recent work using uncemented implants, with or without separate fracture fixation, appear to offer more promising results for this situation. The worry in this situation is the blood supply to the acetabular bone, which is necessary for bony ingrowth or on growth, and which may have been disrupted by the fracture. This same blood supply, however, maybe even more disrupted by fracture surgery.

(c) After early surgical failure

In cases of early surgical failure, sepsis is the cause until proved otherwise, and to assume the presence of AVN or chondrolysis is a mistake. If the patient has increasing pain, and the wound is red, then infection is obvious. A raised ESR and CRP give information, but at times a definitive answer can only be obtained through tissue samples at the time of debridement.

(d) Following successful healing

Beyond 2 years whether treated operatively or not, there is a risk of arthritis associated with even cases who appear to have excellent early results. Beyond 2 years there is a gradual increase in the incidence of arthritis, which continues to rise. In a paper reviewing the outcomes of delayed total hip replacements after acetabular fractures, Borkhoff compared the results with a matched population of hip replacement patients who had not had a previous fracture. The non-operatively treated fracture group were similar to the osteoarthritis group in terms of times to revision hip replacement, whereas the group who had undergone fracture fixation had their hip replacements revised significantly earlier. This was attributed to a number of factors, including the higher rates of infection, heterotopic ossification and sciatic nerve injury. The main technical failures were due to the acetabular component, not the femoral component.

Complications

Complications following acetabular fractures can be considered in three groups – those related to the injury itself (nerve or vessel damage, primary joint damage), early complications (infection, thrombo-embolism, post-surgical nerve damage, surgical bleeding) and late complications (failure of fixation, avascular necrosis, development of heterotopic ossification or degenerative arthritis).Nerve damage Sciatic nerve palsies are common in acetabula fracture cases, with rates up to 40% when there has been a dislocation The tibial nerve portion is more commonly affected since these nerve fibres are situated more anteriorly as the nerve passes behind the hip, and incases where the peroneal nerve is severely affected the likelihood of recovery is lower as nerve is severely damaged. In cases where there is a partial nerve palsy on admission, this is often seen to worsen post-surgery, presumably as a result of a second 'hit' on the nerve or its blood supply. Damage to the sciatic nerve canbe avoided by a combination of careful exposure/retraction, and keeping the knee flexed throughout the procedure, as was recommended by Letourneland Judet in 1993 [21]. Intra-operative nerve monitoring has been tried in an attempt to warn the surgeon before nerve injury occurs, but it has been shown that if the measures suggested by Letournel and Judet are employed then nerve monitoring adds little, and is not cost-effective. Recovery from mild nerve injuries is often complete, especially if the peroneal portion was spared. However, final recovery can take 2–3 years, and patients must be warned of this. In the cases of muscular weakness (usually a foot drop) the appropriate physiotherapy and splints should be arranged while recovery is awaited. In ilio-inginal approaches, the lateral femoral cutaneous nerve of the thigh is in danger, and damage is often unavoidable. The nerve has nomotor function, but the area of sensory supply is surprisingly large, covering much of the lateral thigh. Damage to the superior gluteal nerve can occur in posterior approaches, especially secondary to control of damage to the nearby artery. The bundle exits the pelvis high in the notch, close to the exit point of many posterior column fractures if the blood vessel is damaged, then the nerve must either be carefully identified before the vessel is ligated, or haemostasis can be achieved through packing. Damage to this nerve results in poor abductor muscle function with a subsequent Trendelenburg Gait.

Infection

Infection after any fracture fixation is potentially disastrous, and is especially so in acetabular fractures as not only is the fixation is affects but any future total hip replacement is also compromised. Published infection rates are around 4% and this does not appear to be changing with time. This rate seems high, but these are significant injuries in patients often with polytrauma, and who may be moderately immuno-compromised at the time of surgery. The surgical approach is extensive, often through the zone of injury, and is also necessarily close to the perineum and groin regions. In acute infection the area must be debrided with the removal of all dead and devitilised tissue, and only closed once definitely clean. If necessary wounds can be left open and vacuum dressings used, with regular repeat debridements until clean. Care must be taken to identify a septic arthritis, which also requires debridement and copious joint irrigation provided it is stable, the fixation is retained until union is complete. In later cases of infection after union has occurred, the metal work should be removed, and if necessary a two-stage primary total hip replacement can be performed.

Thromboembolism

Thromboembolic rates are difficult to confirm as many cases are silent. In Steele's paper in 2005, it was shown that not only is it safe to give low molecular weight heparin once the patient is haemodynamically stable, but that it lowered the rate of proximal DVT from 22%to 3%. The overall rate of PE in that study was 5%, which is comparable with other series. Helfet in 1997 reported using MRI venographypre-operatively [which had previously been reportedto be more sensitive than contrast venography and detected pre-operative thrombi in 34% of cases at an average of 7.5 days post injury, and postoperative thrombiin 21% of cases. Many of those cases did not have pre-operative thromboprophylaxis, however. If pre-operative thrombi are detected, then surgery is either abandoned or takes place after fitting of an inferior vena cava filter. At the authors unit all patients are warfarinised once post-operative X-rays are accepted, and warfarin is then continued for 3 months. Using this protocol the PE rate in the lastyear is 53%, but DVT's are rarely investigated as treatment is already in place.

Bleeding

Surgical bleeding can be extensive, especially during extensile approaches. Blood loss and transfusion rates can be minimised by the routine use of a cellsaver, and a retransfusion of 400–800 mL can regularly be achieved – this is the equivalent of up to four units of transfused blood. Where there is an isolated acetabular fracture, and unexplained early blood loss requiring transfusion preoperatively occurs, it is likely that there has been damage to one of the nearby arteries – the superior gluteal, obturator or pudendal. This should act as a warning signal to the surgeon, who can expect re-bleeding to occur during surgery. Significant bleeding can also occur due to damage caused by the drillbit exiting on the far side of fractures, which will often result in a sudden drop in the systolic blood pressure of 15–20 mmHg. If significant bleeding is occurred, the first action is not to panic, and pack the area. If a bleeding vessel can be identified then it is ligated. If not the fracture surgery should be finished, and careful consideration given to angiography.

Fixation failure

Failure of fixation is always disappointing, and in general represents a surgical error. Patients are kept touch-weight bearing after surgery, but significant forces cross the hip joint even at rest, and the fixation achieved on day one must be sound. As in all fracture management, failure of fixation should lead immediately to a suspicion of infection. This may be difficult to prove or rule out, but in cases of infection where the fixation has failed the outcome is rarely good. Management options include suppression of the infection until union takes place, with early metalwork removal, or attempts at salvage possibly with staged removal of metalwork and re-fixation or total hip replacement. In the absence of infection then early revision fixation can be considered, but the stakes are high and it may often be advisable to allow union to occur and consider an early total hip replacement If necessary.

Avascular necrosis

Avascular necrosis can be divided in to AVN of the femoral head or AVN of the acetabular wall. Femoral head AVN is rare, but can be due to direct high energy impacts (in which case it is segmental and corresponds to the area of injury) or due to surgical compromise of the femoral head blood supply. AVN of the acetabular wall occurs predominantly due to injudicious elevation of soft tissues from the fragments, and is also uncommon but is often blamed for failure rather than post-traumatic arthritis secondary to an imperfect reduction. Overall, avascular necrosis is uncommon, even when a dislocation has occurred, and may be as low overall as 5% rising to 9% with a dislocation. Previous studies have shown it to be much higher but the difficulty again is distinguishing between AVN and post-traumatic arthritis. Femoral head AVN can generally be assumed if the acetabular surface appears anatomic, and there is progressive destruction of the femoral head in the absence of intra-articular hardware. Changes are generally present on X-rays by 3–6 months, and are often seen on X-rays before clinical deterioration is apparent. Once significant avascular necrosis has occurred and infection has been ruled out, the most common solution is a total hip replacement

Heterotopic ossification

Heterotopic ossification is not uncommon, and the published rates are up to 25%. This is one of the reasons why extensile exposures such as the extended ilio-femoral are now used less commonly. Prophylaxis against HO can include either radio-therapy or the use of indomethacin. Although no papers exist directly comparing these two methods in acetabular surgery, in revision hip surgery there is little difference between the two. The choice is most commonly made depending on availability, and study shows use of indomethacin for 2–6 weeks. At the authors institute, HO is rarely seen despite the fact that over 100 acetabular fractures are operated on per year. Although indomethacin issued routinely, the feeling is that HO has become less common over the last decade as surgical techniques have improved (including muscle debri-dement prior to closure), and as surgical exposures have become smaller and more elegant. Over the next few years, reported HO rates may be seen to fall significantly from previous published figures.

Post-traumatic arthritis

The most commonly seen complication of an acetabular fracture is post-traumatic arthritis, which can occur at any point after fracture. The overall incidence is probably in the region of 20%, but is dependent on many factors which are discussed below.

Outcomes
Despite the application of standard fracture treat-ment techniques, i.e. anatomic reduction, stable fixation and early mobilisation, a significant number of patients following acetabular fractures have poor outcomes. Most authors present figures in the region of 22% of cases suffering a poor outcome at 2–5 years – the problem with this statement is how the outcome is judged. In any branch of surgery it is imperative that the outcome of a procedure is known, before decisions can be made whether or not to undertake it in each individual case. In the case of acetabular fractures, an ideal outcome tool does not exist, and different investigators use a variety of different methods. The development of arthritis is a tempting outcome measure, but should the arthritis be clinical or radiographic? Specific end-points such as the development of avascular necrosis or infection can be used, but thankfully these do not apply to the majority. Subsequent total hip replacement has also been used, but there are many confounding factors that can sway the decision to undergo arthroplasty, in both the young and the elderly. Most authors use a combination of these surrogate end points, along with scores such as the SF-36 form and hip scores (e.g. Harris Hip Score or the Oxford Hip Score).A further popular scoring system is the Merled'Aubigne score, which combines pain, gait, function and range of motion. With the above in mind, there are certain facts which can be gleaned from the literature. In general, there are factors which cannot be changed, including patient age and bone quality, fracture pattern and extent, nerve and vessel damage, medical comorbidities and associated injuries. Factors which are under surgeon control, however, include time to surgery, surgical approach and technique, reduction achieved, the maintenance of stability and reduction, and the avoidance of further complications. As early as 1961 Rowe and Lowell (1961) concluded that the outcome depends on the condition of the weight bearing dome, the condition of the femoral head, the adequacy of reduction and the stability achieved – all of these principles are true today. Letournel and Judet in 1993 [21] reported that aresidual step in the articular surface of more than 2 mm is predictive of a poor outcome and a higher likelihood of requiring a subsequent arthroplasty. This was supported by Matta in 1996 [27]. The ability to achieve anatomic reduction is time dependent, and has been clearly shown by several authors to be less likely with increasing time post injury. While for associated fracture patterns the cut-off point before outcome is affected appears to be around 11 days, it appears that for simple fracture patterns the cut-off point may be more like 15 days. The delay to surgery leads to an increased amount of scar tissue formation and callus in the fracture lines – this results in a more difficult exposure of less mobile fractures, with indirect reduction manoeuvres being less likely to succeed. In addition, in cases of fractures resulting in the femoral head being subluxed, the rates of femoral head chondrolys is and avascular necrosis increase with delays to reconstruction, and the condition of the femoral head is critical with regards to final outcome. The degree of initial displacement appears to be of less importance, as does the fracture type within the simple or associated fracture groups. Whether patient age is an important factor is debated, but poorer bone quality leads to more fracture fragmentation, a more difficult reduction and less secure fixation, which are all risk factors for a poorer outcome. In general, if a perfect stable reduction can be achieved and maintained, then a good to excellent result can be expected in up to 90% of cases. With less than perfect reductions this drops to below70%, and even lower if stability is not achieved. Degenerative arthritis can occur at any time after fracture, but in the majority of poor outcomes it canbe expected within 2 years. The incidence then slowly climbs over 20 years or more, at times even affecting cases with excellent early result.

Summary
Acetabular fractures are uncommon, and remain within the domain of tertiary referral centres. A cohesive team approach is necessary to ensure the optimal chance of a good outcome, and this requires communication on many levels. Pre-operative assessment must be complete, with life threatening injuries always taking preference, and once haemodynamically stable patients should receive pre-operative thromboprophylaxis. The time from injury to acetabular fracture surgery is of paramount importance, as delays to surgery directly impact on the chances of achieving an anatomical reduction. If the fracture can be reduced anatomically, and the femoral head held stable and parallel under the acetabular dome, then a good to excellent outcome can be expected in most cases.

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